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RESPONSE TO UREA AND AMMONIUM NITRATE FERTILIZATION IN AN 80-YEAR-OLD DOUGLAS-FIR STAND

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Abstract

Volume growth response to 200 lb of nitrogen per acre applied as urea or ammonium nitrate was monitored for 4 yr in an 80-yr-old, site I, Douglas-fir stand. Fertilization increased gross total cubic growth by 20 percent over the controls. Response to urea and to ammonium nitrate was similar. The rapid volume growth on the control plots, 342 ft^3 per acre per year, plus the substantial increase in growth on the fertilized plots, indicate the desirability of delaying final harvest of this stand.

KEYWORDS: Nitrogen fertilizer response, increment (volume), urea, ammonium nitrate, silviculture, Douglas-fir, *Pseudotsuga menziesii*.

INTRODUCTION

Silvicultural treatments that increase growth in mature stands can be attractive financial investments because the initial costs and carrying charges can be quickly recovered from early harvest of high value products. In this Research Note, we present the initial results of a trial in which nitrogen fertilization increased volume growth of an 80-yr-old, site I, Douglas-fir stand. We also compare the effects of urea with those of ammonium nitrate on volume growth.

THE STUDY AREA AND TREATMENT

The study area was an unthinned, nearly pure Douglas-fir stand in the McCleary Experimental Forest[1] in western Washington (fig. 1). Basal area stocking averaged 111 percent of normal (McArdle et al. 1961) and site index (100-yr base) averaged 193 or low site I. The soil is Tebo gravelly loam; annual precipitation averages 66 inches.

We used 12 circular, 1/5-acre plots to compare three treatments: 200 lb of nitrogen per acre as urea, 200 lb of nitrogen per acre as ammonium nitrate, and no nitrogen (control). We randomly assigned four plots to each treatment. Most stand characteristics were similar among treatments (table 1).

We applied the fertilizers by hand on April 13, 1973, to 1/2-acre plots centered on the 1/5-acre measurement plots; this provided a 30-ft-wide buffer. The weather during application was cloudy and cool; about an inch of rain fell during the 3 days following treatment. Thus, nitrogen losses by volatilization were probably minimized.

[1]Maintained by the Pacific Northwest Forest and Range Experiment Station in cooperation with Simpson Timber Company.

Figure 1.--A portion of the 80-yr-old, unthinned stand in the McCleary Experimental Forest.

Table 1--Initial stand characteristics of study plots in the McCleary Experimental Forest, per acre basis

Characteristic	Treatment			
	Control	Urea	Ammonium nitrate	Average
Age (years)	80	78	80	79
Site index (100-year base)	190	198	191	193
Stems (number)	159	121	135	138
Average diameter[1/] (inches)	19.3	21.3	21.0	20.5
Basal area (square feet)	324	298	324	315
Volume (cubic feet)	18,952	17,566	18,760	18,426
Percent Douglas-fir	99	98	99	99

[1/] D.b.h. of the tree of mean basal area.

MEASUREMENTS AND ANALYSES

Our 12 study plots were some of the control plots of a thinning experiment that began in 1949 (Reukema and Pienaar 1973); consequently, we had prefertilization growth data. We remeasured the trees immediately before fertilization and 4 yr after fertilization. We measured diameter at breast height (d.b.h.) of all trees 1.6 in and larger and recorded their crown class and condition. We also determined the heights of nine trees on each plot; two-thirds of these trees had diameters greater than average d.b.h. Based on these height trees, we calculated an average tarif number and thus a volume equation to estimate total stem volume for each plot in each measurement year.

We examined the effect of treatment on 4-yr volume growth and mortality. Because growth and mortality prior to fertilization varied among the plots, we used covariance analysis to adjust for these differences. We tested two variables as covariates: cubic-foot volume at the beginning of the study and periodic annual increment (p.a.i.) in basal area during a 14-yr period prior to fertilization. Insufficient height data during the prefertilization period precluded our using pretreatment volume growth as a covariate. The analyses using p.a.i. in basal area (pretreatment) as the covariate were more effective in reducing the effects of pretreatment differences among the plots. In the results of these analyses which follow, we used the 10-percent probability level ($P<0.10$) to judge differences as real or statistically significant. The orthogonal comparisons, control vs. fertilized and urea vs. ammonium nitrate, were used to separate treatment means.

RESULTS AND DISCUSSION

Response to nitrogen fertilization was significant ($P<0.04$).

When treatment means were adjusted for differences in pretreatment growth rates, volume growth on the fertilized plots averaged 20 percent greater than that on the control plots (table 2). This equaled an average 4-yr increase of 280 ft^3 per acre. There was no significant differences between response to urea and response to ammonium nitrate. Volume loss to mortality during the 4-yr period after fertilization varied greatly among the plots and treatments (table 2). Due to this variability, mortality losses were not significantly affected by treatment ($P<0.68$).

This response to fertilization was somewhat lower than that measured in an earlier study of fertilization of individual trees in a thinned portion of the same stand (Miller and Reukema 1974). The six fertilizer treatments in that study increased average basal area growth 31 percent over the controls during a 5-year period after fertilization. Ammonium nitrate (300 lb of nitrogen per acre) increased basal area growth 53 percent, while urea (300 and 600 lb of nitrogen per acre) increased growth 31 and 22 percent. Due to the variability in response, however, only the ammonium nitrate treatment differed significantly from the control.

The difference in fertilizer response measured in the two studies could be explained by a number of factors. For example, the individual tree study used six codominants for each treatment, whereas our study used 1/5-acre plots and thus had both greater tree numbers and crown class representation. The earlier study also used higher rates of nitrogen per acre. In addition, response to fertilization by individual trees is likely to be greater in a thinned stand than in an unthinned stand, because light is more likely to limit growth in an unthinned stand (Brix 1971).

Volume growth measured in this 80-yr-old stand was surprisingly large. Gross periodic annual growth on the four control plots averaged 342 ft^3 per acre compared with reported estimates of 263 (Staebler 1955) and 287 (Curtis 1967) ft^3 per acre for normal stands of the same site index and age. Having checked our procedures and calculations, we have no reason to doubt the accuracy of our growth estimates. Moreover, our estimates of stand volume and growth are supported by previous estimates (Reukema

Table 2--Mean annual volume growth and mortality in an 80-year-old, Douglas-fir stand during a 4-yr period after treatment, per acre basis [1/]

Treatment	Volume growth [2/]		Mortality [2/]
	Cubic feet	Percent	Cubic feet
Control	342	100	75
Urea	409	119	140
Ammonium nitrate	415	121	65

[1/] Cubic volume of the total stem of trees 1.6-in d.b.h. and larger.

[2/] Means adjusted by covariance analysis.

and Pienaar 1973). For example, earlier periodic annual growth for these and other unthinned plots in this stand progressed from 263 ft^3 per acre at age 56 to 285 ft^3 at age 71. This trend of increasing volume growth over time indicates that gross growth in this stand has not yet culminated. Thus, delaying the final harvest of this stand is an attractive management option.

CONCLUSIONS

In this 80-yr-old stand of Douglas-fir:

1. Urea or ammonium nitrate applied at 200 lb of nitrogen per acre increased gross volume growth 20 percent over the controls during the first 4 years following treatment. This was an average increase 280 ft^3 per acre.
2. Ammonium nitrate and urea provided the same gain in volume growth.
3. Fertilization did not significantly change the volume lost to mortality.
4. Gross volume growth of the control plots has not peaked; therefore, delaying final harvest should be evaluated.

Based on the results at this location and others,[2] we believe nitrogen fertilization is an efficient means for increasing total yields in mature Douglas-fir stands.

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Metric Equivalents

1 square foot/acre = 0.2296 square meters/hectare
1 cubic foot/acre = 0.06997 cubic meters/hectare
1 stem/acre = 2.471 stems/hectare
1 inch = 2.54 centimeters

[2]Unpublished data on file at the Forestry Sciences Laboratory, Pacific Northwest Forest and Range Experiment Station, Olympia, Washington.

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